Future Flavor Physics At Fermilab?

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U.S. DOE Office of Science Head (Ray Orbach) Remarks, Feb 2007.

- In his remarks to HEPAP following the release of the ILC Reference Design Report, Undersecretary Orbach requested a dialog with the HEP community:

"In making our plans for the future, it is important to be conservative and to learn from our experiences. ***Even assuming a positive decision to build an ILC, the schedules will almost certainly be lengthier than the optimistic projections.*** *Completing the R&D and engineering design, negotiating an international structure, selecting a site, obtaining firm financial commitments, and building the machine could take us well into the mid-2020s, if not later. Within this context, I would like to re-engage HEPAP in discussion of the future of particle physics. If the ILC were not to turn on until the middle or end of the 2020s,* ***what are the right investment choices to ensure the vitality and continuity of the field*** *during the next two to three decades and to maximize the potential for major discovery during that period?"*

What is happening at Fermilab?

- The ILC is Fermilab's highest priority. Both the R&D and bidding for the site. The FY-2008 US budget has ~$80M for the ILC and SCRF development, which is more than double the current FY-2007 budget. Resources are increasing day by day for ILC R&D, and in many cases at the expense of other well motivated initiatives.

- Recognition that TODAY a fast construction start determined from a technically driven schedule is not likely. In hindsight this is not very surprising, but disappointing to many.

- World-wide ILC strategy is now actively being discussed, emerging view that an "Engineering Design Report" for the accelerator and detectors should be ready around 2010 in order to react to possible new physics seen at the LHC.

Oddone's Charge to the "Fermilab Futures" Steering Group

"The Steering Group should consider the Fermilab based facilities in the context of the global particle physics program. Specifically the group should develop a strategic roadmap that:

- supports the international R&D and engineering design for as early a start of the ILC as possible and supports the development of Fermilab as a potential host site for the ILC;
- **develops options for an accelerator-based high energy physics program in the event the start of the ILC construction is slower than the technically-limited schedule**; and
- includes the steps necessary to explore higher energy colliders that might follow the ILC or be needed should the results from LHC point toward a higher energy than that planned for the ILC. "

Execution, Context, Timescale of Oddone's Charge

Execution: The Fermilab Deputy Director (Young-Kee Kim) is leading the steering group. The steering group has several advisory bodies including a Flavor Physics Group that is investigating opportunities in B-physics, anti-proton physics, kaon physics and muon physics.

Context: The scale of potential resources is some fraction of the U.S. operational costs of the PEP-II/Babar and Tevatron Collider programs (together about $100M/year) which will cease operations at the end of the decade.

Timescale: Pier Oddone asks for a report from the Steering Group on August 1st 2007, and will encourage promising directions after this.

Flavor Physics Group Considerations

- New large scale flavor experiments (>$200M) will be very challenging to fund. The earliest that medium-scale experiments could be operational is 2012, hence the Flavor group should consider experiments that would operate 2012-2022.

- Large enhancements to the accelerator complex (such as a proton-driver) will not be available at the start of this period.

- A possible evolution of the existing accelerator complex has been studied in some detail, and serves as a reference for the future flavor experiment considerations. In all cases, feeding a proton-driven flavor program will tax a coincident neutrino physics program.

- The timescale of August 1st precludes proposals or detailed LOIs. There is however time for restating the physics case in light of where flavor physics is today, and outlining a conceptual experimental program based on previous work such as the RSVP, CKM, KaMI, and SuperB proposals.

Conceptual Flavor Experiments Being Discussed

- Mounting the Super-B experiment in the Tevatron collider complex.

- A 8 GeV p-pbar experiment for a high sensitivity charm experiment.

- Kaon Experiments:
  - A next-generation K+ decay experiment starting with 10^{-12} SES/year.
  - A next-generation K_L decay experiment starting with 10^{-11} SES/year.
  - A high purity, high intensity K^0 beam experiment.

- A high sensitivity muon-to-electron conversion experiment (ala MECO)

Next-Generation K^+ decay Experiment Starting with 10^{-12} SES/year.

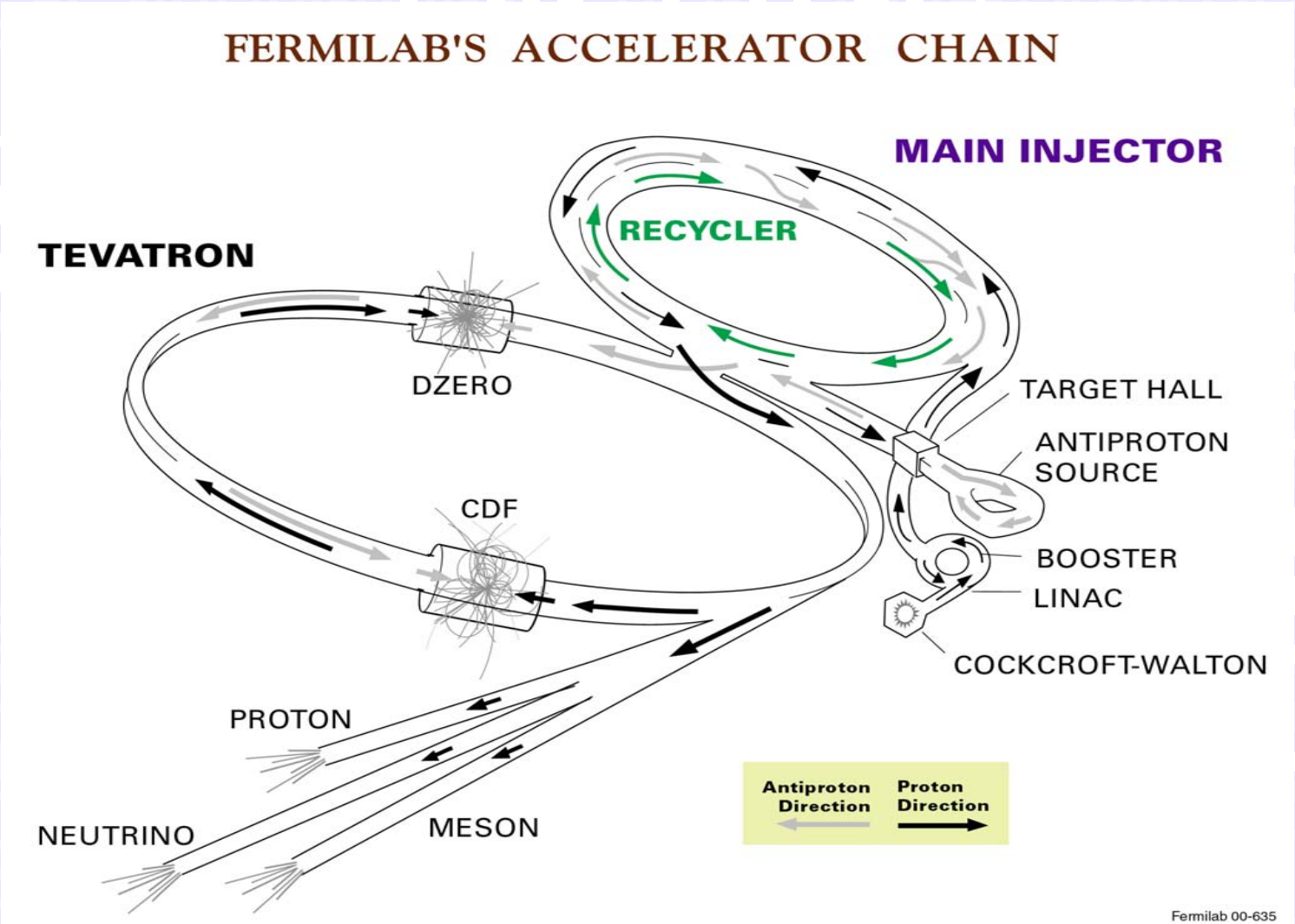
- Accelerator model discussed: One of ten Main Injector (120 GeV, 900 kW protons) pulses is injected into the Tevatron running at 120 GeV and stretched in time to a 100% Duty Factor.

  This 120 GeV DC proton beam drives a separator system built from 3.9 GHz ILC Crab cavities to deliver a 15 MHz, 25 GeV K^+ beam that is 70% pure at the detector. (CKM beam separator design)

- Following the CKM detector design, 100-200 $K^+ \to \pi^+ \nu\bar{\nu}$ decays per year are possible, matching the expected theoretical error in 2012 on the branching ratio of 3-4% with several years of running.

The relatively low rates and open geometry of the CKM design enables consideration of a next generation Lepton Flavor Violation experiment following precision measurement of $K^+ \to \pi^+ \nu\bar{\nu}$. Improving limits on $K^+ \to \pi\mu e$ and $K^+ \to \pi^- \mu^+ \mu^+$ by x100 and x1000 are plausible.

Fermilab Accelerator Complex



A Next-Generation K_L Decay Experiment Starting With 10^{-11} SES/year.

- Accelerator model discussed: A modification of the 8 GeV Fermilab Booster/Accumulator complex to generate the time structure of the KOPIO experiment required to measure the K_L momentum event by event.

- A preliminary study of yields suggest that sufficient K_L flux with respect to the 24 GeV AGS beam can be recovered with smaller targeting angles.

- Following the KOPIO detector design, 10's of $K^0 \rightarrow \pi^0 \nu \bar{\nu}$ decays per year are plausible.

- A higher energy KaMI-like experiment similar to JPARC E14 is not considered since such a similar approach would be several years behind JPARC E14.

A High Purity, High Intensity K^0 Beam Experiment.

- The concept of generating a relatively pure high energy and high intensity K^0 source through charge-exchange from a 25 GeV pure K^+ beam has been discussed previously in a 1999 proposal to Fermilab.

What can be probed with such a novel facility? Some ideas….

A next generation interferometer: No dilution factor means maximal interference. Neutron and hyperon rates are low so access to low proper-time close to the target is plausible.

- Can push CPT, Quantum self-entanglemement coherence limits.

- Can consider an interference experiment in $K^0_L \to \pi^0 e^+e^- / K^0_S \to \pi^0 e^+e^-$ to access the CP violating component.

What's Next, Summary

- Engage the community in a discussion of what is the optimal path to advance flavor physics. What are the best ideas for Fermilab? Contact me, contact the steering group.

- $K \to \pi \nu \bar{\nu}$ decays have enjoyed a compelling physics case. The case for Lepton Flavor violation, Lepton Universality, CPT tests, Quantum Coherence tests are not as well appreciated by the broader community. As a flavor community we need to improve this situation to motivate future facilities.

  What new mass-scale reach exists at 100 TeV?, 1000 TeV??

- The case for next-generation experimental kaon concepts is best served by advancing our current new initiatives. Next generation concepts will build on the success of CERN E326, JPARC E14, and possible extensions of the KLOE flavor program.